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Indirect Search for Dark Matter with AMS

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Abstract. This document summarises the potential of AMS in the indirect search for Dark Matter. Observations and cosmology indicate that the Universe may include a large amount of Dark Matter of unknown nature. A good candidate is the Lightest Supersymmetric Particle in R-Parity conserving models. AMS offers a unique opportunity to study Dark Matter indirect signature in three spectra: gamma, antiprotons and positrons.

1. Introduction

Cold Dark Matter makes up about 23% of the energy of the universe. Supersymmetry or models with extra dimensions provide viable candidates to Dark Matter; their annihilations in the Galactic Halo are an exotic source of photons, antiprotons and positrons. Their predicted fluxes can be enhanced if the Dark Matter is distributed in clumps. The AMS-02 spectrometer is a multi-purpose detector described in detail in [1]. Its key features relevant to indirect dark matter searches are a 0.5 m^2 geometrical acceptance, a very good energy resolution in the GeV to TeV range and redundant particle identification.

2. Gamma flux measurements

In AMS-02, gamma identification can be performed via two methods: either gammas are converted in the .25 radiation lengths of the TRD and are signed by 2 opposite charged tracks with low invariant mass or photons shower directly in the calorimeter with no other activity in the detector.

These methods have complementary acceptances, the first one being efficient down to 2 GeV with a maximum acceptance of $0.06 \text{ m}^2.\text{sr}$ at 30 GeV while the second one is efficient to high energy with a maximum of $0.097 \text{ m}^2.\text{sr}$ at 200 GeV. Both methods have a similar time integrated sensitivity to the Galactic Center.

As shown in the figures 1 et 2, AMS will be sensitive to some models of Supersymmetry and Kaluza-Klein especially in the case of an optimistic Dark Matter distribution towards the Galactic Center.

3. Antiproton flux measurements

Antiprotons are identified by their negative charge in the tracker and a hadronic signature in the TRD. The main background originating from protons interactions outside the sensitive volume is removed by severe quality cuts. Acceptance for antiprotons is $0.160 \text{ m}^2.\text{sr}$ in the range 1 to 16 GeV and $0.033 \text{ m}^2.\text{sr}$ up to 300 GeV.

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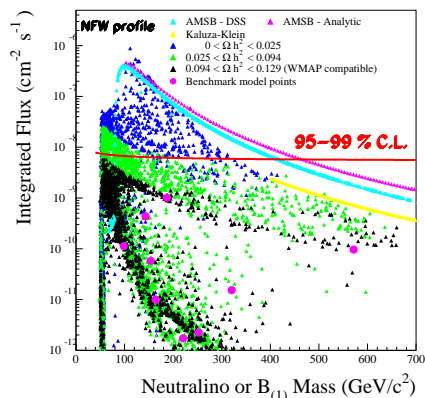


Figure 1. Expected gamma flux as a function of the Dark Matter candidate mass for a wide scan of supersymmetry and Kaluza-Klein models in the case of a conventional NFW (1,1,2) [2] profile. The expected AMS sensitivity is represented by the line.

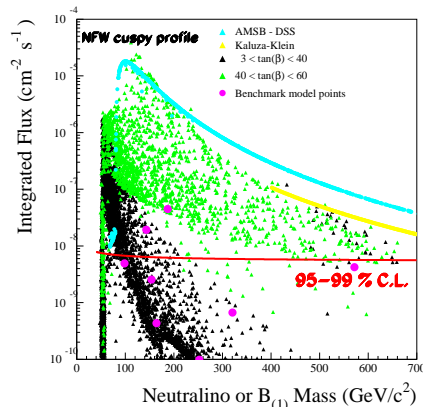


Figure 2. Expected gamma flux as a function of the Dark Matter candidate mass for a wide scan of supersymmetry and Kaluza-Klein models in the case of an optimistic NFW(1.5,1,1.5) [2] profile. The expected AMS sensitivity is represented by the line.

The antiproton spectrum is presently measured between 200 MeV and 20 GeV and is explained by a secondary production only [3]. A signal could appear at energies larger than 30 GeV, originating for instance from a heavy neutralino, but then large boost factors are needed in order to give a sufficient signal [4].

4. Positron flux measurements

Positrons are identified by requiring an electromagnetic signature in the TRD and the calorimeter. In addition, the energy measured by the calorimeter should be compatible with the momentum measured in the tracker. All these requirements lead to an average acceptance of $0.042 \text{ m}^2 \cdot \text{sr}$ [5], [6], [7] above 4 GeV.

In the Minimal SuperSymmetric Model, predicted positrons fluxes require large boost factors in order to be detected by AMS. However, models with large $\tan \beta$ or models where the gaugino mass universality is broken request substantially lower boost factors. This is shown in figures 3 and 4.

5. Conclusion

AMS has a unique opportunity to measure simultaneously the gamma, antiprotons and positrons spectra, increasing its sensitivity to Dark Matter search or leading to better constraints on the models.

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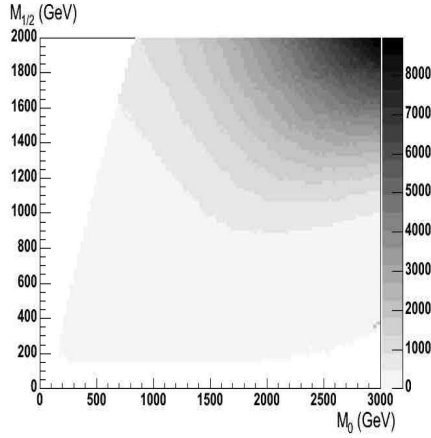


Figure 3. In the plane $M_{1/2}$ M_0 , the grey scale represents the minimal boost factor for AMS to be sensitive in the case of large $\tan \beta$ ($\tan \beta = 40$).

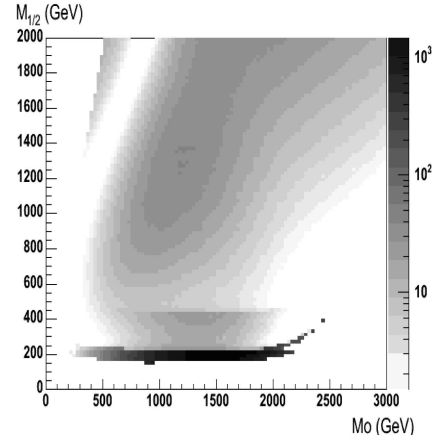


Figure 4. In the plane $M_{1/2}$ M_0 , the grey scale represents the minimal boost factor for AMS to be sensitive in the case of where the gaugino mass universality is broken ($M_3 = 50\% M_{1/2}$)

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